

UNITED STATES PATENT APPLICATION  
for

**THERMAL INTERFACE MEDIUM**

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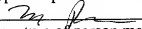
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## THERMAL INTERFACE MEDIUM

### BACKGROUND OF THE INVENTION

5 Internal components of electronic devices, such as computers, become heated after a period of use. The increased heat increases heat resistance, resulting in decreased system performance. Performance may be restored or improved by cooling the electrical components using a heat exchanger, a device that transfers heat from a hot body to a cold  
10 body via conduction or convection. Conduction refers to the transfer of heat or electricity between different parts of a substance as a result of a difference in the temperature in the case of heat, or as a result of a difference on electric potential, in the case of electricity. The rate of heat flow between two regions is proportional to the temperature difference between them and the heat conductivity of the substance.

15 Heat may be transferred between two bodies simply by bringing the bodies into contact with each other. Thus in the simplest form, a heat exchanger typically consists of a warm body coupled with a cooler body. However, simply touching two bodies together rarely yields an efficient transfer of heat, as the mating surface of the two bodies often contain irregular ties that create air gaps between the surfaces. Because air does not transfer  
20 heat as well as other substances, such as metal, for example, the air gaps reduce the efficiency of heat transfer.

A more efficient means of exchanging heat between two bodies is to insert a thermal interface material between the mating surfaces. The thermal interface material conforms to

the irregularities present in each mating surface and improves heat transfer by reducing or eliminating air pockets. Using a thermal interface material is generally less costly than matching the mating surfaces to have mirror-like finishes. Examples of conventional interface materials include thermal greases or gels. Metallic particles are often embedded in  
5 the grease or gel to improve the interface material's heat transfer properties. However, the metallic particles suspended in the grease or gel are often separated by spaces occupied by grease or gel. Heat applied to the interface material is transferred through the particles filed gel at different rates, first through a gel filled space and then through a metallic particle or cluster of particles, or vise versa. Because grease or gel transfers heat less efficiently than  
10 metal, the thermal transfer rate of the particle/grease combination is limited by the grease filled spaces between the particles.

The present invention provides a material that overcomes several of the problems common in the art using a pattern of thermally conductive, malleable fibers.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which

- 5           Figure 1 illustrates the architecture of a conventional heat transfer assembly;
- Figures 2a-2b illustrate a prior art thermal interface medium;
- Figures 3a-3b illustrate one embodiment of the thermal interface medium,
- Figures 4a-4c illustrate one embodiment of a stacked thermal interface medium;
- Figures 5a-5b illustrate one embodiment of a random thermal interface medium;
- 10           Figures 6a-6b illustrate one embodiment of a woven thermal interface medium;

**DETAILED DESCRIPTION**

A thermal interface medium is disclosed. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one of ordinary skill in the art that these specific details need not be used to practice the present invention. In other circumstances, well-known structures, materials, circuits, processes and interfaces have not been shown or described in detail in order not to unnecessarily obscure the present invention.

Referring now to Figure 1, a diagram of a conventional heat transfer assembly is illustrated. Thermal plate 101 is cooled by convection or other cooling means well known in the art so as to have a cooler temperature than heat source 105. In this conventional network architecture, heat source 105 may be an integrated circuit or other electronic element used in the manufacture and operation of an electronic device such as a computer, a personal digital assistant, stereo, or other similar device. The warm or hot temperature of heat source 105 results from the flow of electric current in heat source 105 or results from heat produced by elements coupled with heat source 105. Thermal interface medium 103 is positioned between thermal plate 101 and heat source 105 to allow the efficient transfer of heat from heat source 105 to thermal plate 101. In conventional manufacturing processes, the surface 102 of thermal plate 101 and the surface 104 of heat source 105 contain irregularities. If surface 102 is positioned to contact surface 104 directly, the efficiency of heat transfer between the two bodies is reduced by air gaps caused by the irregularities in the

5 mating surfaces. For this reason, thermal interface medium 103 is provided to thoroughly mate surface 102 with surface 104.

Referring now to Figure 2, another example of a conventional heat transfer assembly is illustrated. As shown in Figure 2a, an interface material 203 is coupled with heat source 205 in preparation to mate with thermal plate 201. Conventional interface material 203 is usually a thermal gel or grease having heat transfer properties. Metallic particles are randomly distributed throughout the material to improve its heat transfer properties. When interface material 203 is compressed between thermal plate 201 and heat source 205, as shown in Figure 2b, a plurality of metallic particles come into contact with each other to form a plurality of discontinuous metallic paths 213. Because metal typically has a higher thermal transfer rate than grease due to the extra free electrons inherent in metal, heat will typically flow more efficiently and quickly along the discontinuous metallic paths 213 than it does through the grease filled spaces 211 between the metallic particles 207. The grease filled spaces 211 limit the thermal transfer rate of the interface material.

15 The present invention is used in a heat transfer environment. Figure 3 illustrates a thermal interface material 300 according to one embodiment. As shown in Figure 3a, the thermal interface material 300 includes a plurality of thermally conductive, malleable fibers 307 embedded in a grease or gel 303. The material 300 is coupled with heat source 305, in preparation to mate with thermal plate 301. In contrast to the metallic particles shown in 20 Figures 1 and 2, the thermally conductive, malleable fibers 307 are generally continuous along their respective lengths. The fibers 307 may be made a metal, a metal alloy, a metal

compound, or combinations thereof, such as, for example copper or silver. Alternatively, fibers 307 may be made of a non-metal, such as carbon fiber or graphite. In one embodiment, the architecture illustrated in Figure 3a may be fashioned of a single fiber.

When compressed by thermal plate 301, as illustrated by the embodiment shown in  
5 Figure 3b, the material 300 deforms, forcing the fibers 307 into substantially continuous or continuous contact with each other, to form substantially continuous or continuous metallic paths that allow efficient heat transfer between heat source 305 and thermal plate 301. Grease filled gaps 311 may still exist, but the number and quality of the thermal transfer connections is improved; and the conformed interface material thermally behaves in unison  
10 similar to a one piece material with high thermal properties, without exhibiting the technical issues (thermal stress, CTE, etc.) associated with such a material.

In one embodiment, thermal interface material 300 includes thermally conductive malleable fibers immersed in a suitable medium such as thermal grease or gel. The metallic fibers 307 can be configured in multiple patterns, such as, for example, stacked, random, and  
15 woven. Exemplary patterns are described in more detail below. The interface material 300 is sandwiched between surface 304 of heat source 305 and surface 302 of thermal plate 301, and is especially adept to high toleranced stack up assemblies. Once the assembly is secured, the conductive fibers 307 deform and conform to the mating surfaces 302, 304, and contact each other, making continuous or substantially continuous "paths" of metal (or non-  
20 metal) for efficient heat transfer. The grease or gel 303, rather than acting as the primary medium for heat transfer, acts as a supplementary vehicle aiding the conductive fibers by

reducing or eliminating voids between the interface material 300 and mating surfaces 302, 304.

Referring to Figure 4, a stacked pattern of thermally conductive, malleable fibers is shown. As illustrated in Figure 4a, stacked pattern 400 is manufactured by layering  
5 substantially parallel rows of fibers 401 substantially orthogonally on top of each other to form a grid. The grid includes fibers 401 of a size and spacing appropriate for the particular application. For example, fibers 401 comprising the grid may be microscopic in size, or substantially larger.

Referring to Figure 4b, a cross sectional view of stacked pattern 400, taken along the  
10 direction of arrows A in Figure 4a, is shown. The fibers rest on each other when deformed, and transfer heat longitudinally and laterally in three dimensions through the interface material.

Referring now to Figure 4c, the lateral and longitudinal distribution of heat in a stacked pattern 400 is illustrated. In this Figure, heat 411 is transferred to pattern 400 from  
15 hot section 409 of heat source 407 and, ripples laterally and substantially concentrically outward in three dimensions through the interface material, such that the heat 411 is quickly absorbed by the interface material and transferred to section 405 in thermal plate 403. Section 405 may have a surface area less than or greater than the surface area of section 403. A similar three dimensional transfer of heat occurs with respect to the patterns shown in  
20 Figures 5 and 6.



Referring to Figure 5, a random pattern of thermally conductive, malleable fibers is shown. Figure 5a is an overhead view of random pattern 500, and Figure 5b is a cross sectional view of woven pattern 500 taken along the direction of arrows B in Figure 5a. Random pattern 500 illustrated in Figure 5a and Figure 5b may be fashioned using a plurality of fibers 501 or from a single fiber tangled together in a random fashion.

In one embodiment, a pattern of fibers may be manufactured in a relatively large sheet or block, and then cut into a plurality of pieces that are individually sized for use in particular applications. The materials comprising the patterns and the pattern configurations may be varied to fit a particular application. The fiber(s) 501 may be manufactured using any one of a number of extruding, injecting, or infusing processes known in the manufacturing arts.

Referring to Figure 6, a woven pattern of thermally conductive, malleable fibers is illustrated. Figure 6a is an overhead view of woven pattern 600, and Figure 6b is a cross sectional view of woven pattern 600 taken along the direction of arrows C in Figure 6a. Woven pattern 600 may be manufactured using a single fiber 601 or a plurality of fibers. The pattern may be incorporated in a thermal grease or gel, or used without a thermal grease or gel. In one embodiment, an adhesive material, of a type commonly known in the adhesive and manufacturing arts, may be applied to woven pattern 600 or other pattern of thermally conductive, malleable fibers to attach the pattern to a surface in preparation to mate with another surface. For example, the adhesive material may be applied to the pattern of thermally conductive, malleable fibers. The pattern can then be positioned adjacent to a

surface and stuck in place. At a later time, the pattern may be compressed by pressure applied to another surface placed adjacent the pattern to deform the pattern and conform it to the mating surfaces. In one embodiment, the pattern may be replaced by removing the old pattern and adhering a new one. At least three illustrative patterns have been shown and described, however, the present invention is not limited to these examples, but includes additional patterns.

Although the present invention is described herein with reference to a specific preferred embodiment, many modifications and variations therein will readily occur to those with ordinary skill in the art. Accordingly, all such variations and modifications are included within the intended scope of the present invention as defined by the following claims.